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Sir:

Transmitted herewith for filing is a PROVISIONAL APPLICATION of

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for **A METHOD OF PROVIDING A PURIFIED, VIRUS SAFE ANTIBODY PREPARATION**. The application comprises a 14-page specification and 2 sheets of drawings.

Accompanying this application for filing is:

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## **A method of providing a purified, virus safe antibody preparation**

The present invention concerns a method of preparing a purified, virus safe antibody preparation from a starting solution comprising antibodies and  
5 contaminants. It describes a purification process of gamma-globulins from human plasma and other sources. Virus inactivation and removal steps are included in the manufacturing process described here.

### **Precipitation and resulting virus removal/inactivation**

In the 1940s Cohn et al. introduced the cold ethanol fractionation of human  
10 plasma. Several variations of this scheme came up to increase the purity and/or yield of the different intermediates. In Cohn fractionation some steps were identified to contribute efficiently to virus inactivation and removal. In the IgG process especially the separation of Cohn I+III fraction is very effective in this respect. Some sensitive viruses (mainly enveloped viruses) are destroyed by low  
15 pH and EtOH presence and a great part of enveloped and non-enveloped viruses is removed by partitioning in the precipitate I+III which is usually discarded.

In the 1960s it was shown that short fatty acids (C6-C12) form insoluble complexes with  $\alpha$ - and  $\beta$ -globulins whereas  $\gamma$ -globulins are not as readily precipitated (Chanutin et al., 1960). Steinbruch et al (1996) described a  
20 purification process for IgG with caprylate (i.e. octanoate, a C8-saturated fatty acid) as precipitating agent. Non-immunoglobulins were precipitated from human plasma after dilution with an acetate buffer to reach a final pH of 4.8. After addition of caprylate under vigorous stirring an IgG enriched solution was obtained. The purity and yield depended on the amount of caprylic acid, the pH,  
25 the molarity of the buffer and the dilution factor. Steinbruch et al. also stated that it is advantageous to add the effective amount of caprylate in two steps with the removal of the precipitates inbetween. Non-enveloped and enveloped viruses are removed by partitioning in the precipitate of the non IgG proteins as is the case for the separation of the I+III fraction.

### **Chromatography**

Several patents describe the purification of IgG solution in the so called negative mode; IgG runs through without binding (only in traces) whereas the majority of the non-IgG fraction proteins bind to the anionic ligands (Bertolini et al. 1998,

WO-A-98/05686; Lebing 1999, US-A-5,886,154; Friesen et al., 1986, CA 1201063). The combination of caprylate precipitation followed by ion-exchange chromatography for the purification of IgG was described in many publications. One of the first was written by Steinbuch et al. (1969). He described the further  
5 purification of IgG after precipitation of caprylate with DEAE-cellulose. The recent publication by Lebing et al. (2003) describes two anion-exchange columns used in series for the removal of IgM, IgA, albumin and other impurities. Lebing et al. combined both caprylate mediated effects, namely the essential reduction of non-IgG proteins by precipitation, thereby using the virus partitioning, and the  
10 enveloped virus inactivation properties of the fatty acid in a separate incubation step. The importance of the so-called "pH-swing" Lebing et al. (2003), starting from the reconstitution of an IgG containing paste/precipitate at pH 4.2 and the subsequent addition of caprylate upon adjusting the pH 5.2 is stressed to be essential for the IgG enriching procedure, thus needed to effectively reduce non-  
15 IgG proteins. As a few other impurities, like IgA and IgM, as well as the caprylate were subsequently reduced by the mentioned ion exchange chromatography steps.

Surprisingly we found that such pH-shift as outlined above and described by Lebing et al. is not needed to achieve a significant purification effect upon  
20 caprylate addition and removal of the resulting precipitate. Instead, upon keeping the pH constant at pH 4.8 to 4.95 during the entire process of paste reconstitution and caprylate incubation and precipitate removal, an effective IgG enrichment is achieved. Also the amount of impurities especially albumin is reduced more efficiently by keeping the pH constant in the range of 4.8 to 4.95.  
25 At the same time viruses are removed. Afterwards residual impurities and caprylate are separated by ion exchange steps.

#### Classical virus inactivation

The solvent detergent and pH 4 treatments are well known methods and widely  
30 used for immunoglobulins. The SD treatment is normally introduced into these processes due to its superiority in terms of inactivation of enveloped viruses (Biesert L. Clinical and Experimental Rheumatology 1996; 14: 47). Both enveloped and non-enveloped viruses are affected by the exposure to low pH, although enveloped viruses are more affected than the non-enveloped (Biesert.

Clinical and Experimental Rheumatology 1996; 14: 47, Bos et al. Biologicals 1998; 26: 267, In Seop et al. J Microbiol Biotechnol 2001; 11: 619).

In EP-A-0 525 502 the combination of solvent detergent and pH 4 incubation as virus inactivation steps are described.

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#### Virus filtration

IgG solutions are filtered through membranes of very small pore size (typically 15 to 40 nm) under conditions that retain viruses by a mechanism largely based on size exclusion (Burnouf and Radoševich. Haemophilia 2003; 9: 24) to increase the virus safety. Also depth filters designed to retain viruses by ion exchange adsorption are used for filtration of immunoglobulins.

10

#### Summary of the invention

The invention describes a purification process of IgG with an increased yield and shorter process time compared to the classical Cohn-Onclay fractionation process. IgG is reconstituted in buffer at an acidic pH range from 4.80 to 4.95, preferentially 4.9. Non-IgG proteins are separated by two incubation steps with caprylate at a concentration range from 10 to 30 mM caprylate, preferably 20 mM.

15

For effective inactivation of enveloped viruses, an incubation known as solvent detergent treatment with Triton X-100, Tween 80 etc. and TNBP, can be added to increase the virus inactivation capacity of the entire process. A virus removal by filtration, i.p. by the so-called nanofiltration or charged depth filters may be added to the virus removal procedures.

20

Furthermore, caprylate/caprylic acid can be combined with or replaced by heptanoate/heptanoic acid to perform the aforementioned precipitation and incubation process steps.

25

30

## Detailed description of the invention

The invention concerns a method of preparing a purified, virus inactivated and virus safe antibody preparation from a starting solution comprising antibodies and contaminants, the method comprising the steps of:

- 5 (a) adjusting the pH of the starting solution to about 4.8 to about 4.95 to produce an intermediate solution;
- (b) adding caprylate and/or heptanoate ions to the intermediate solution and maintaining the pH at 4.8 to 4.95 whereby a precipitate is formed and the antibodies are essentially present in the supernatant;
- 10 (c) incubating the supernatant solution under conditions of caprylate and/or heptanoate ion concentration, time, pH and temperature; optionally concentrating and diafiltrating the filtered solution before pH adjustment;
- (d) applying the filtered solution with at least one anion exchange resin and optionally with two different anion exchange resins under conditions that allow  
15 binding of contaminants to the resin while not allowing significant binding of the antibodies to the resin, wherein a purified, virus inactivated and virus safe antibody preparation is produced.

In one embodiment of the invention the virus inactivated solution is contacted in step (d) with the at least one anion exchange resin at pH of from about 5.0 to  
20 5.2.

Typically, the starting solution comprises plasma-derived antibodies.

It may be advantageous to contact in step (d) the inactivated solution with two different anion exchange resins under conditions such that contaminants are selectively bound to the resins while the antibodies are not significantly bound to  
25 the resins.

Preferably, the antibodies are of the immunoglobulin G-type.

Between the two anion-exchange chromatography (AEX) steps the pH is in particular changed to  $6.8 \pm 0.1$ . The AEX flow through may be concentrated to 60 to 90 mg/ml and diafiltrated against phosphate buffer. In another  
30 embodiment of the method of the invention the flow through of the first AEX is solvent detergent treated, preferably by Triton X-100 and TnBP, preferably at concentrations of 1% Triton X-100 and 0.3% TnBP for 4.5 to 8 hours to

inactivate lipid coated viruses. The method is known as solvent-detergent-treatment and disclosed in EP-A-0 131 740 (incorporated by reference). According to the invention, the detergents of the incubation mixture are in particular removed by solid and liquid phase extraction. After solid phase  
5 extraction the pH of the solution is adjusted to 6.7 to 6.9.

The solution thus adjusted can be applied to the second AEX column where the AEX flow through is pH adjusted to 3.5 to 4.5, in particular  $4.0 \pm 0.1$ . According to the invention the pH adjusted IgG solution is contacted by a virus filter.

Additionally the IgG solution can be incubated at  $37^{\circ}\text{C} \pm 1$  for at least 24 hours.

10 The IgG solution obtained according to the invention is typically concentrated to concentration of 5 or 10 % and the osmolarity of the concentrate is adjusted to 200 to 400 mOsmol/kg by an appropriate additive. Such additives are well known to the expert and include but are not limited to sugars, sugar alcohols and amino acids. The IgG solution may be pH adjusted to 3.5 to 6.0, in particular 4.0  
15 to 5.5. Finally, the IgG solution is sterile filtered and filled in glass bottles or plastic containers. Alternatively, the flow through after the first or second AEX step is applied to nanofilters to achieve an even safer product.

The process of invention is described in more detail, preferentially performed as outlined:

20 As starting material human plasma fraction I+II+III or fraction II+III was used. These fractions were produced as described by Cohn et al. (1946). The adjustment of the pH during the process was done with 1 M acetic acid, 0.1 M NaOH or 0.3 M HCl. Caprylate was added as a 1 M sodium caprylate stock solution. This stock solution was prepared by dissolving 166 g of sodium  
25 caprylate in 1 liter of water for injections (WFI) and stirring until total dissolution of sodium caprylate.

Exemplary for the SD treatment Triton X-100 and TnBP Tween 80 were used. For the removal of the SD reagents vegetable oil such as soy bean oil or castor oil were used.

30 All reagents were USP grade or better.



Quantitative size exclusion chromatography and ELISA were used to determine the IgG concentration. Analytical HPLC was done with an Agilent HPLC System with TosoHaas G3000SW column.

A schematic drawing of the process is shown in figure 1. The process starts with the dissolving of the IgG precipitate, called paste, in purified water. Usually the higher the volume of water to reconstitute the paste the higher is the yield of IgG. The pH of the solution is adjusted to 4.80 to 4.95, preferably to 4.90 with 1 M acetic acid. The solution is stirred for several hours to get as much IgG as possible in solution. Afterwards caprylate is added as a 1 M stock solution up to concentrations between 10 and 30 mM, preferably 20 mM caprylate. The pH during the addition of caprylate is kept constant between 4.80 and 4.95, preferably at 4.90. During the incubation of the IgG solution with caprylate non-IgG proteins and lipids precipitate. The formed precipitate is removed by filtration from the IgG solution. After the first precipitation step some impurities remain in the IgG solution. Therefore a second caprylate treatment is necessary. Similar to the first step the caprylate is added as 1 M stock solution up to a concentration of approximately 20 mM caprylate in solution at a constant pH between 4.80 and 4.95, preferably at 4.9. After the incubation the precipitate is removed by filtration or centrifugation. For a better performance during the filtration filter aid is used. The filtered solution is adjusted to a pH between 5.0 and 5.2, preferably to 5.1 and applied to an anion-exchange column. As an anion exchange column, preferably strong anion exchangers such as Q-Sepharose-FF, Q-Sepharose HP, Q-Sepharose-XL, Source Q 15 or 30 (Amersham Bioscience), Q-Thruput, Q-Thruput plus (Sterogene), Macro Prep Q and Macro Prep High Q (BioRad), Q Hyper D (BioSeptra) and Poros HQ (PerSeptive Biosystems) were chosen. The IgG flows through the column under the chosen conditions, whereas some additives/impurities such as caprylate and IgA bind to the resin. The protein solution is loaded onto the column at a ratio of 40 to 90 mg protein per ml resin. The obtained flow through is concentrated to a protein concentration of 60 to 90 mg/ml, preferably 70 mg/ml and diafiltrated against 5 volumes of phosphate buffer with a concentration of 5 to 20 mM, preferably 10 mM sodium phosphate. As an optional virus inactivation step the SD treatment can be chosen after the diafiltration. The diafiltrated solution is then virus inactivated using the SD treatment described by Horowitz e.g. in EP-A-0 131 740. As SD reagents TnBP

and Triton X-100 were used. After stirring, the solution is incubated up to 8 hours at a temperature between 4 and 10°C. Then a vegetable oil such as soy bean oil or castor oil, preferably castor oil is added to the solution up to a concentration of 3 to 5 % (w/w). After the separation of the oily phase from the aqueous phase, the aqueous phase is filtrated. Therefore an appropriate depth filter is used. Examples for these filters are Polysep II (Millipore), Sartofine PP and Sartobran P (Sartorius). The subsequent solid phase extraction is performed in a preferred mode using a hydrophobic support media which are also used in reversed phase chromatography with a gel matrix made of silica, styrene-co-divinyl benzene (SDVB), glycidyl methacrylate-co-ethylene dimethacrylate or polyaromatic. Examples for these media are µBondapak (Waters), Amberchrom CG-161 M and S, Amberchrom CG-070 (Tosoh Biosep), PLRP-S (Polymer Laboratories), RPC-1 and Toyopearl Hexyl 650C (Tosoh Biosep), Source 15 RPC (Amersham Biosciences), LiChroprep Si60 (Merck), Chromabond Sorbent HR-P and EASY (Machery-Nagel), ProntoSORB SPE (Bischoff Chrom.). The protein solution is loaded onto the column in a ratio of 0.5 to 1.5 mg/ml dry resin. The flow through of the solid phase extraction (or chromatography step, respectively) is adjusted to a pH between 6.7 and 6.9, preferably 6.8 by the addition of 0.1 M NaOH at a temperature between 4 and 10°C. Afterwards the IgG solution is applied to a second anion exchange column. The IgG flows unretained through the column, whereas impurities and polymers bind to the column. As an anion exchange column, preferably strong anion exchangers such as Q-Sepharose-FF, Q-Sepharose HP, Q-Sepharose-XL, Source Q 15 or 30 (Amersham Bioscience), Q-Thruput, Q-Thruput plus (Sterogene), Macro Prep Q and Macro Prep High Q (Bio-Rad), Q Hyper D (BioSeptra) and Poros HQ (PerSeptive Biosystems) were chosen. The column is equilibrated with a 10 mM sodium phosphate buffer. After the application of the IgG solution the column is washed with equilibration buffer to obtain all non bound IgG from the column. The protein solution is loaded onto the column at a ratio of 120 to 190 mg protein/ml resin. The collected IgG solution is adjusted to a pH between 3.9 and 4.1, preferably 4.0 with 0.3 M HCl at a temperature between 4 and 10°C. Then the solution is sterile filtered and stored at 37°C for at least 24 hours. Subsequent to the low pH treatment the pH of the solution is adjusted to 4.7 with 0.1 M NaOH at a temperature between 4 and 10°C. As an additional virus reduction step appropriate virus filters can be used. For virus filtration the IgG solution was filtered through a 0.1 µm filter

followed by virus filters with a pore size between 200 and 15 nm. Examples for these filters are DVD, DV 50, DV 20 (Pall), Viresolve NFP, Viresolve NFR (Millipore), Planova 75, 35, 20, 15N (Asahi Kasei Pharma). Also a charged depth filter like Zeta Plus VR (Cuno) can be used. This filtration step can also be applied after pH 4 incubation. Preferably this step will be implemented in the process before the low pH treatment. The highly purified IgG solution is diafiltered and concentrated to the final formulation values. As final concentrations for a liquid formulation protein concentrations of 5 or 10% (w/v) were chosen. After the concentration the osmolarity is adjusted to be compatible for intravenous injection by an appropriate additive. Sugars, sugar alcohols and amino acids can be used. The pH is checked again and adjusted to 4.5 to 5.0, preferable to 4.7. Subsequently another sterile filtration is carried out and the solution is filled into infusion bottles.

The following examples explain the process of invention in more detail:

Example 1:

The Cohn fraction I+II+III or II+III was dissolved in 12 volumes of water, the pH was adjusted to 4.9 with 1 M acetic acid and the solution was stirred for up to 5 hours until most of the IgG was dissolved at a temperature of 2 to 8°C. Afterwards caprylate was added as a 1 M sodium caprylate stock solution to the IgG solution up to a concentration of 20 mM caprylate while keeping the pH constant at 4.9 by adding 1 M Acetic acid. This solution was stirred for one hour. Lipids and impurities precipitated under these conditions and were removed by filtration. Afterwards caprylate was added again to the solution up to a concentration of 20 mM in solution upon keeping the pH constant at 4.9. Again a precipitate was generated and removed by filtration. A clear solution was obtained after the filtration. The solution was adjusted to a pH of 5.1 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to Source Q 30 column. The IgG solution flew through the column whereas the impurities and caprylate were bound to the column. The collected IgG solution was concentrated to a protein concentration of 70 mg/ml and diafiltered against 5 volumes of a phosphate buffer pH 5.1. Subsequently, 0.3 % (w/w) of TnBP and 1 % (w/w) of Triton X-100 were added to the solution, followed by vigorous stirring. After at least 4.5 hours of stirring at  $7 \pm 3^\circ\text{C}$ , 5 % (w/w) of castor oil is added. The oil extraction

was performed at room temperature. The oily and aqueous phases were separated and the aqueous phase was filtrated with a Millipore Opticap Polysep filter. The filtered solution was applied to a column filled with a reversed phase matrix named  $\mu$ Bondapak (Waters). Then the solution was adjusted to pH of 6.8 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to a strong anion exchanger, namely Q-Sepharose-XL. The IgG ran through the column whereas the impurities were bound to the column. The pH of the collected IgG solution was adjusted to 4.7 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$ . Again an ultrafiltration was carried out to adjust the protein concentration to the final concentration of 50 or 100 mg/ml, followed by the addition of maltose to a concentration range from 2 to 10 % (weight), preferably 8 % or glycine in a concentration range from 0.1 to 0.3 M. preferably 0.2 M. Subsequently to the following sterile filtration, the solution was filled into sterilized and siliconized infusion bottles with different volumes (50, 100, 200 ml). The bottles were sealed by stoppers.

#### Example 2:

This example in particular differs from example 1 by the implementation of a pH 4 incubation step. The Cohn fraction I+II+III or II+III was dissolved in 12 volumes of water, the pH was adjusted to 4.9 with 1 M acetic acid and the solution was stirred for up to 5 hours until most of the IgG was dissolved at a temperature of 2 to  $8^\circ\text{C}$ . Afterwards caprylate was added as a 1 M sodium caprylate stock solution to the IgG solution up to a concentration of 20 mM caprylate in solution and the pH was kept constant at 4.9 by adding 1 M acetic acid. This solution was stirred for one hour. Lipids and impurities precipitated under this circumstances and were removed by filtration. Afterwards caprylate was added again to the solution up to a concentration of 20 mM upon keeping the pH constant at 4.9. Again the formed precipitate was removed by filtration. A clear solution was obtained after the filtration. The collected IgG solution was concentrated to a protein concentration of 70 mg/ml and diafiltered against 5 volumes of a phosphate buffer pH 5.1. The solution was adjusted to a pH of 5.1 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to the strong anion exchanger Q-Sepharose-XL. The IgG flew through the column whereas the impurities and caprylate were bound to the column. Subsequently, 0.3 % (w/w)

of TnBP and 1 % (w/w) of Triton X-100 were added to the solution, followed by vigorous stirring. After at least 4.5 hours of stirring at 4 to 10°C, 5 % (w/w) of castor oil was added. The oil extraction was performed at room temperature. The oily and aqueous phases were separated and the aqueous phase was filtrated with a Millipore Opticap Polysep filter. The filtered solution was applied to a column filled with Amberchrom CG-161M. Then the solution was adjusted to pH of 6.8 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to the strong anion exchanger Q-Hyper D. The IgG flew through the column whereas the impurities were bound to the column. The pH of the collected IgG solution was adjusted to 4.0 with 0.3 M HCl at a temperature of  $7 \pm 3^\circ\text{C}$ . The solution was sterile filtrated and stored at  $37 \pm 3^\circ\text{C}$  for at least 24 hours. Afterwards the pH of the solution was adjusted to 4.7 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$ . Again an ultrafiltration was carried out to adjust the protein concentration to the final concentration of 50 or 100 mg/ml to be obtained after formulation with maltose or glycine. Subsequently to the following sterile filtration, the solution was filled into sterilized and siliconized infusion bottles with different volumes (50, 100, 200 ml). The bottles were sealed by stoppers.

### Example 3:

This example in particular differs from the former samples by concentration the IgG solution to 70 mg/ml protein concentration before the first AEX step and by implementation of a nanofiltration step.

The Cohn fraction I+II+III or II+III was dissolved in 12 volumes of water, the pH was adjusted to 4.9 with 1 M acetic acid and the solution was stirred for up to 5 hours until most of the IgG is dissolved at a temperature of 2 to 8°C. Afterwards caprylate was added as a 1 M sodium caprylate stock solution to the solution up to a concentration of 20 mM caprylate in solution and the pH was kept constant at 4.9 by adding 1 M acetic acid. This solution was stirred for one hour. Lipids and impurities precipitate under these conditions and were removed with filtration. Afterwards caprylate was added again to the solution up to a concentration of 20 mM upon keeping the pH constant at 4.9. Again a precipitate was generated and removed by filtration. A clear solution was obtained after the filtration. The collected IgG solution was concentrated to a protein concentration

of 70 mg/ml and diafiltered against 5 volumes of a phosphate buffer pH 5.1. The solution was adjusted to a pH of 5.1 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to a strong anion exchanger. The IgG flew through the column whereas the impurities and caprylate were bound to the column. Then the  
5 solution was adjusted to pH of 6.8 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$  and applied to a second strong anion exchanger. The IgG passed through the column whereas the impurities were bound to the column. The pH of the collected IgG solution was adjusted to 4.0 with 0.3 M HCl at a temperature of  $7 \pm 3^\circ\text{C}$ . The solution was filtrated through a  $0.1 \mu\text{m}$  filter, afterwards a cascade of  
10 PALL filters namely PALL DVD, DV 50 and DV 20 with a pore sizes starting down to 20 nm were used for nanofiltration. The nanofiltered solution is stored at  $37 \pm 3^\circ\text{C}$  for at least 24 hours. Afterwards the pH of the solution was adjusted to 4.7 with 0.1 M NaOH at a temperature of  $7 \pm 3^\circ\text{C}$ . Again an ultrafiltration was carried out to adjust the protein concentration to the final concentration of 50 or 100  
15 mg/ml to be obtained after formulation with maltose or glycine by the addition of maltose or glycine. Subsequently to the following sterile filtration, the solution was filled into sterilized and siliconized infusion bottles with different volumes (50, 100; 200 ml). The bottles were sealed by stoppers.

**Claims**

1. A method of preparing a purified, virus inactivated and virus safe antibody preparation from a starting solution comprising antibodies and contaminants,  
5 the method comprising the steps of:
  - (a) adjusting the pH of the starting solution to about 4.8 to about 4.95 to produce an intermediate solution;
  - (b) adding caprylate and/or heptanoate ions to the intermediate solution and maintaining the pH at 4.8 to 4.95, whereby a precipitate is formed and  
10 the antibodies are essentially present in the supernatant;
  - (c) incubating the supernatant solution under conditions of caprylate and/or heptanoate ion concentration, time, pH and temperature optionally concentrating and diafiltrating the filtrated solution before pH adjustment;
  - 15 (d) applying the filtered solution with a least one anion exchange resin and optionally with two different anion exchange resins under conditions that allow binding of contaminants to the resin while not allowing significant binding of the antibodies to the resin, wherein a purified, virus inactivated and virus safe antibody preparation is produced.
- 20 2. The method of claim 1 wherein in step (d) the virus inactivated solution is contacted with the at least one anion exchange resin at a pH from about 5.0 to 5.2.
3. The method of claim 1 wherein the starting solution comprises plasma-derived antibodies.
- 25 4. The method of claim 1 wherein in step (d) the inactivated solution is contacted with two different anion exchange resins under conditions such that contaminants are selectively bound to the resins while the antibodies, are not significantly bound to the resins.
5. The method of claims 1-4, wherein the antibodies are immunoglobulin G.
- 30 6. The method of claim 4, where the pH is adjusted to pH  $6.8 \pm 0.1$  prior to the second anion-exchange chromatography.

7. The method of claim 1, wherein the anion-exchange chromatography flow-through is concentrated to 60 to 90 mg/ml and diafiltrated against a buffer solution, preferably a phosphate buffer.
8. The method of claim 1, wherein the flow-through of the first anion-exchange chromatography is solvent detergent treated, preferably by Triton X-100 and TnBP, most preferred by concentrations of 1% Triton X-100 and 0.3% TnBP for 4.5 to 8 hours to inactivate lipid coated viruses.
9. The method of claim 8, the detergents of the incubation mixture of which are removed by solid and liquid phase extraction.
10. The method of claim 9, wherein the pH value upon solid phase extraction is adjusted to 6.7 to 6.9.
11. The method of claim 10, wherein the solution is submitted to the second anion-exchange chromatography.
12. The method of claim 11, wherein the pH value of the anion-exchanger flow-through is adjusted to 3.5 to 4.5, preferably to pH  $4.0 \pm 0.1$ .
13. The method of claim 12, wherein the IgG solution is contacted by a virus filter.
14. The method of claim 12, wherein the IgG solution is contacted by a nanofilter.
15. The method of claim 12 wherein the IgG solution is incubated for at least 24 hours, preferably at  $37^{\circ}\text{C} \pm 1$ .
16. The method of claim 12, wherein the IgG solution is concentrated to 5 or 10%.
17. The method of claim 16, wherein the osmolarity of the concentrate is adjusted to 200 to 400 mOsmol/kg by an appropriate additive.
18. The method of claim 17, wherein the IgG solution is pH adjusted to 3.5 to 6.0, preferred to a pH value of 4.0 to 5.5.
19. The method of claim 18 wherein the IgG solution is sterile filtered and filled in glass bottles or plastic containers.

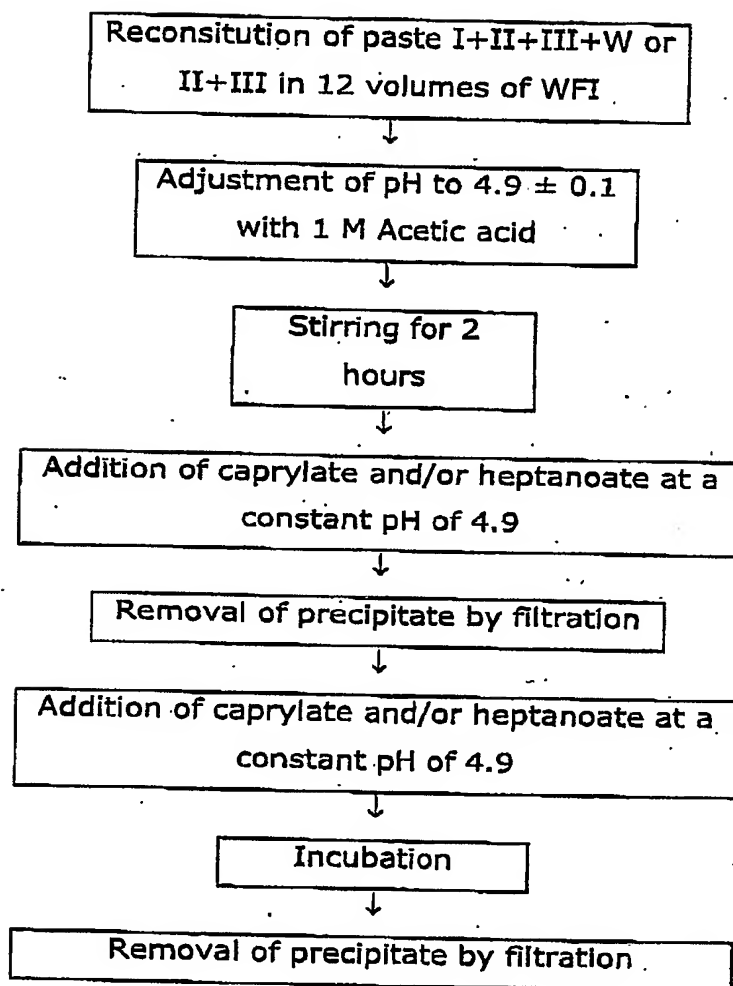


**Abstract**

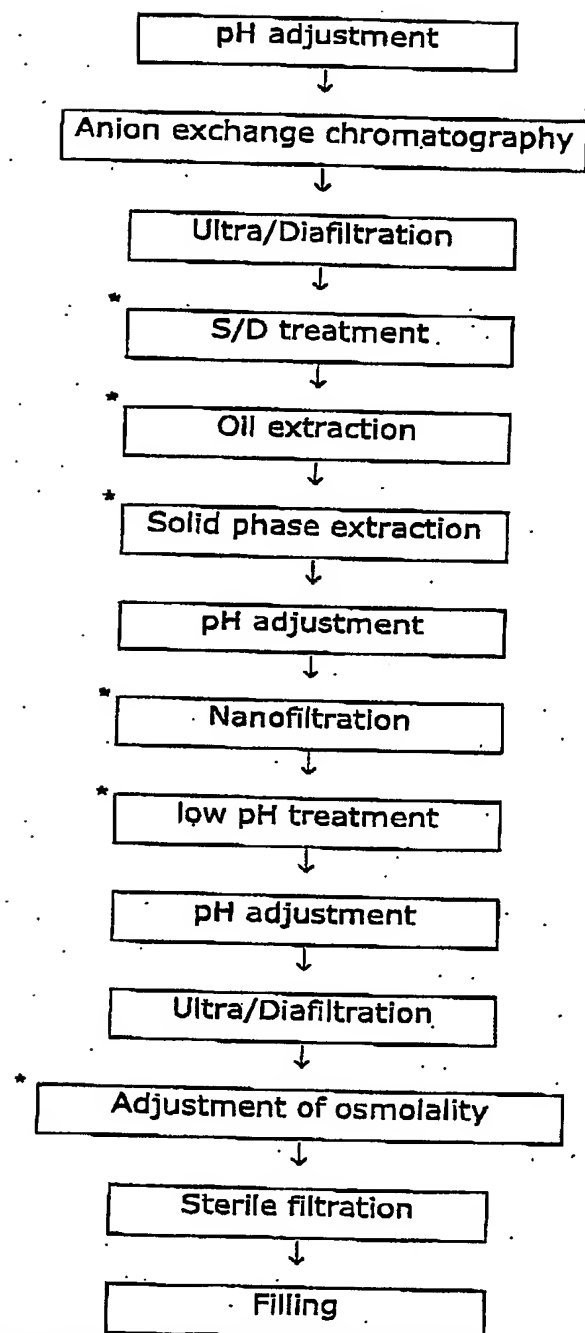
A method of preparing a purified, virus inactivated and virus safe antibody preparation from a starting solution comprising antibodies and contaminants, the method comprising the steps of:

- (a) adjusting the pH of the starting solution to about 4.8 to about 4.95 to produce an intermediate solution;
- (b) adding caprylate and/or heptanoate ions to the intermediate solution and maintaining the pH at 4.8 to 4.95, whereby a precipitate is formed and the antibodies are essentially present in the supernatant;
- (c) incubating the supernatant solution under conditions of caprylate and/or heptanoate ion concentration, time, pH and temperature optionally concentrating and diafiltrating the filtrated solution before pH adjustment;
- (d) applying the filtered solution with a least one anion exchange resin and optionally with two different anion exchange resins under conditions that allow binding of contaminants to the resin while not allowing significant binding of the antibodies to the resin, wherein a purified, virus inactivated and virus safe antibody preparation is produced.

**Figure 1**



**Figure 2**



All boxes with an asterisk are optional process steps.